

CLAIMS

1           1. A charge pumping system capable of a forward operation mode and a  
2 reverse operation mode, wherein in forward operation mode the charge pumping  
3 system can step-up an input voltage at a ratio of  $\frac{1}{2}$ :1 and can step-down the input  
4 voltage at a ratio of at least one of 1:1, 3:2, 2:1 and 3:1, and wherein in reverse  
5 operation mode the charge pumping system can step-down the input voltage at a ratio  
6 of  $1:\frac{1}{2}$  and 1:1 and can step-up the input voltage at a ratio of at least one of 2:3, 1:2  
7 and 1:3.

1           2. The system of claim 1 comprising:  
2           a first node operable to be connected as either an input node or an output node  
3 for the system; and  
4           a second node operable to be connected as either an input node or an output  
5 node for the system.

1           3. The system of claim 1 comprising a switching component operable to be  
2 configured to set the ratio for step-up or step-down for the forward and reverse  
3 operation modes.

1           4. The system of claim 3 wherein the switching component comprises a  
2 fractional switch having a plurality of segments.

1           5. The system of claim 4 further comprising a control circuitry for turning on  
2 one or more segments of the fractional switch.

1           6. The system of claim 5 wherein the control circuitry implements a PFM  
2 technique to turn on the segments.

1           7. The system of claim 1 wherein the system is implemented in a single  
2 monolithic semiconductor die.

1           8. A charge pumping system capable of a forward operation mode and a  
2 reverse operation mode, the system comprising:  
3           a first node operable to be connected as an input node in the forward operation  
4 mode and as an output node in the reverse operation mode;  
5           a second node operable to be connected as an input node in the reverse  
6 operation mode and as an input node in the forward operation mode;  
7           wherein in forward operation mode the charge pumping system can step-up an  
8 input voltage at a ratio of  $\frac{1}{2}:1$  and can step-down the input voltage at a ratio of at  
9 least one of 1:1, 3:2, 2:1 and 3:1, and wherein in reverse operation mode the  
10 charge pumping system can step-down the input voltage at a ratio of  $1:\frac{1}{2}$  and 1:1  
11 and can step-up the input voltage at a ratio of at least one of 2:3, 1:2 and 1:3; and  
12           a switching component connected to the first node and the second node, the  
13 switching component operable to be configured to set the ratio for step-up or step-  
14 down for the forward and reverse operation modes, the switching component  
15 comprising at least one fractional switch having a plurality of segments.

1           9. The system of claim 8 further comprising a control circuitry for turning on  
2 one or more segments of the fractional switch.

1           10.           The system of claim 9 wherein the control circuitry implements a  
2 PFM technique to turn on the segments.

1           11.           The system of claim 8 wherein the system is implemented in a  
2 single monolithic semiconductor die.